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ABSTRACT

While the expansion of worldwide hypermedia systems has opened new gateways in the information industry, the result has been material being archived faster than it can be read. Users need to be able to scan information quickly and have more control in information seeking and retrieval. A new area of research is in the development of multimedia tools that answer these needs. One of the aims in the development of MUSLI (MUlti Sensory Language Interface) is to integrate dynamic abstract symbolism into hypermedia technology (linked multimedia documents embedded in a network), allowing for more efficient information retrieval and communication. In a MUSLI movie, users can stop and display additional information as they need and skim condensed versions of a document, searching for relevant sections before breaking down the symbols to display pertinent information. MUSLI documents incorporate material processes ("doing"), mental processes ("sensing"), and relational processes ("being"); these processes are brought together with dynamic symbols. The proposed system will be flexible enough to blend traditional forms of documentation into modern multimedia information retrieval systems while gradually becoming enriched with its own symbolic language. (Contains 22 references.) (AEF)

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MUSLI*
A MUlti-Sensory Language Interface

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Abstract: While the expansion of worldwide hypermedia systems has opened new gateways to an undreamt-of commerce in information, this has led to valuable material being archived faster than it can possibly be read. In this paper we suggest, as a new and vitally important area of research, the development of multimedia tools that allow more efficient and effective "reading" and "writing" using new types of hypermedia documents. We look beyond traditional hypertext, taking the first steps towards a language of dynamic abstract symbols that will help authors to express precisely and concisely both concrete and abstract ideas. MUSLI readers will enjoy searching for detailed information by invoking new multimedia "speed reading" techniques.

1. Introduction

In spite of, and partly because of, dramatic advances in information technology, keeping up to date in any discipline is now almost an impossibility. We know that hypertext systems are available which offer certain solutions to the problem of efficient information retrieval (Maurer, Kappe, Scherbakov, & Srinivasan, 1993; Nielsen, 1990). However we need more help than systems such as these are currently providing.

Although Socrates in Plato's *Phaedrus* argued that writing a language destroys it, reading text is certainly a faster method for gaining information than listening to an orator! Yet we now have a generation of young people many of whom find reading "too slow". People need to be able to scan information as well as good speed readers can scan printed text, or even better. We need to have more control over our communicating media, the level of information we feel motivated to reach, and the pace we wish to set ourselves. Both at leisure and at work we are now accustomed to a very rich proportion of pictorial information in communication; and the importance of visual information must not be underestimated. In particular, certain types of animated pictures may well be worth more than a large number of static ones. Unfortunately we are still severely limited by the lack of tools for producing documents that involve all the senses. One of the aims of MUSLI (MUlti Sensory Language Interface) is to integrate dynamic abstract symbolism ("abstract movies") into hypermedia technology, allowing the efficient expression of ideas difficult to communicate otherwise.

In this paper we use the term "hypermedia" to mean linked multimedia documents embedded in a network. We restrict ourselves to exploring asynchronous communication in hypermedia systems even though

* The Name MUSLI evolved from MUSIL – MUlti Sensory Information Language. The original choice was apt since it is also the name of the famous Austrian poet and novelist Robert Musil (1880-1942), who was not only a master of that abstract communication device, language, but employed language on a notably abstract level in "inner monologues" or "streams of consciousness" – the technique familiar to readers of James Joyce's novels. The new name, MUSLI: A MUlti-Sensory Language Interface, is appropriate in another sense – nutritious cuisine for mind and body!

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synchronous communication may well give rise to still more exciting and challenging research. For example, Maurer and Carlson (1992) point out that although our second most important sensory organ, the ear, has a counterpart, the mouth, our eyes have no such counterpart. We cannot project mental images for other people to capture. The authors suggest that hypermedia systems may develop to a stage where we can produce concrete and abstract projections of our mental images, by computer, so easily and naturally that they will provide us with a new dimension in communication capable of transforming our lives. As wide-area and broad-band networks expand we have an increasingly powerful medium for communication and collaboration, whose impact will not be simply to tie information together but, much more significantly, to "tie people together" (Maurer, 1993a). This, coupled with the fact that multimedia machines are becoming increasingly powerful and affordable, implies that we have the mechanics for truly interactive hypermedia communication systems. Tools for generating new types of hypermedia documents must be developed so that we can make more efficient use of information than is currently possible.

In this paper we shall introduce two new ways of "writing" multimedia material in forms that will aid "reading". We shall expand the idea of browsing and take the first steps toward introducing a more flexible system for conveying information – MUSLI.

Humanity has evolved so many ingenious systems of communication since civilisation first dawned that it makes sense to look briefly at a few of these before we propose a new one.

2. Alternative Forms of Communication

One of the most striking features about communication using signs and symbols is the tremendous variety in medium and form – from the simplest runes on clay or parchment to the most intricate designs on human skin. Prehistorians believe that many ancient cave drawings found in France can be considered as forms of writing: they have discovered groups of drawings which taken together form codes (Jean, 1989). Paintings in the Renaissance were richly redolent with emotionally charged symbolism. Carvings on wood, stone and metal range from concrete signs to abstract symbolism. Signalling devices range from smoke signals to systems of bells, mirrors and musical instruments, to semaphore and electric morse-code – and in the future we are bound to discover new options using digitised sound. Cistercian monks who practise vows of silence have developed highly refined systems of gestures (Umiker-Sebeok, & Sebeok, 1987). Many signs used by deaf people today (Jeanes, 1982) are based on these and it is significant that in many respects signing can convey meaning more quickly than spoken language.

3. The Basic Idea

MUSLI combines hypermedia techniques with the novel idea of dynamic abstract symbols. We aim to facilitate communication by developing a system in which ideas can be expressed as clearly, precisely, and artistically as desired while giving readers the deep satisfaction of using a rich and highly meaningful medium they can control. This paper is to be seen as the very first step, an initial contribution that we hope will encourage scientists to work at opening up new realms in presenting, archiving and communicating ideas.

Obviously any new human endeavour that is worthwhile requires an initial investment of effort. Learning any new language demands dedication and since the system we propose includes abstract symbols it is certain to be no exception.

It is a well known fact that good readers are often disappointed when they see the film version of a book they have read. The problem is often due to the fact that while books leave room for personal interpretation and imagination, movies do not. The "beautiful mountain" of the book will "look different" in the minds of different readers, but all viewers of a movie see, inevitably, the same "beautiful" mountain. What has happened is that there has been a shift in the level of abstraction – the abstract notion "beautiful mountain" has been replaced by a concrete version of a mountain. In MUSLI the proportion and level of abstraction can be chosen to fit the situation, varying from abstract to very concrete as the movie producer feels is appropriate to communicate exactly what is desired.

It is an interesting observation that ideas can be thought of as having the form of a mountain (Maurer, 1992) and it is significant that we talk about having a "point of view" on a topic. As an example of looking at something in more than one way consider the well known problem in first year computer science courses of calculating the Fibonacci series. Many books use this example to teach recursion and then almost apologise for

mentioning that it can be solved better using iteration[1]. Very few lecturers indeed show a third way of looking at the problem using dynamic programming. Yet each of the three methods provides insights that are valid and complementary views of the problem. In an interactive multimedia system students can compare ideas to an even greater extent than ever before.

In any multimedia presentation readers should certainly be able to stop and start at will, rewind, review, and then resume. The system should also enable readers to master new material by building up additional skills as they go. In a MUSLI movie (i.e., a hypermedia document that includes special moving abstract symbols) users can stop and display additional information – at any time they feel ready for it. As explained in Section 7, any group of symbols can be condensed to a single "short-form", and double-clicking on the composite symbol will decompose it again. This gives the user significant control over the amount of data on the screen at any particular time. The user will be able to obtain additional detailed information about scenes, characters, ideas, etc. when it is relevant to them, as well as readily refreshing their memory if they have forgotten the meaning of a symbol. This reference facility in itself will give MUSLI documents significant advantages over traditional books.

More significantly, users will be able to skim condensed versions of a document, searching for relevant sections, before decomposing the symbols to display pertinent information. With facilities such as these, it will be possible to speed-read MUSLI documents faster than printed text.

As systems become available that include electronic personal assistants (Cypher, 1993; Maurer, 1993b; Zissos, & Witten, 1985) readers of MUSLI documents will obtain further help in overcoming the widespread problem of information overload. The system will "learn" what level of detail needs to be displayed so that the "reader" can access needed information more efficiently.

4. What MUSLI is Not

The system we propose must not be misunderstood. It enhances traditional multimedia documents. We propose to extend communication, not restrict it! MUSLI is not simply a system of cartoons – cartoons are designed to be understood without any investment in learning and are quite close to a simplified reality. MUSLI is not a silent movie or some system of signs. It will make appropriate use of computer graphics (2D and 3D), cartoons, audio clips (music and speech both analogue and digital), video clips (analogue and digital), photographs (digitised), animation including 3D modelling; and of course text. Naturally there will still be movies – we delight in the work on human animation being done by scientists and artists such as those at the MIRALab at the University of Geneva (Magnenat-Thalmann, & Thalmann, 1991). Visualisation will continue to be an important means of communication (IEEE, 1993) and we watch with interest the work being done in the field of virtual reality. It is our hope that all of these achievements will be eventually integrated into a single grand design: MUSLI.

5. Using Sound, Speech and Text

Sound can frequently be used to good effect. There is hardly a better way of setting moods for scenes and indicating such things as a really good thunderstorm than by using appropriate sounds. An interesting point made by Alty (1993), is that peripheral or parallel streams of information containing redundant information can be of importance in helping students understand complex ideas.

Although speech is inherently slow, there may be alternative ways of processing it. We note, for example, that it is now possible for computers to play back speech at twice the recorded speed and still maintain an acceptable level of pitch and clarity.

One interesting idea, that should be considered further, is to extend the use made of digitised speech. For example, for scanning purposes, users could display on the screen the waveform patterns of the speech. It may be possible to search for particular sections to play by learning to "read" waveforms, at least in a broad sense; for example, changes in volume may indicate passages of significance. If the wave patterns are expanded and the

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[1] Some warn of arithmetic overflows though what really overflows is time, not size! If m = f(n) is the n'th Fibonacci number, then the recursive function: function f(n: integer): integer; if(n=1) or (n=2) then f := 1 else f := f(n-1) + f(n-2); takes O(m) steps to compute. Since $m = O(c^n)$ with c~1.4 it takes exponential time to compute f(n). The size of f(n) measured in the number of digits, however, grows only linearly!

amplitude is displayed in, say, red while the pitch is displayed in blue, additional information can be gained. In particular, it should be possible to search digitised speech more efficiently than at present. For example, alternating passages of high and low pitch may well mark dialogue. Exciting passages will stand out. Sentences will be seen marked off from one another and other information will be visible such as the occurrence of a question. If the author of the document provides signposts in the form of icons alongside key passages the users will be further aided in their searches. It should also be possible for specialised computer programs to scan the material in greater detail. With methods such as these authors will be able to produce documents allowing "readers" to understand ideas more readily.

The possibility of incorporating existing systems of signs and gestures is an interesting alternative to both speech and text and needs further research (Dreyfuss, 1972).

6. A First Tentative Proposal

In our move towards a theory of dynamic abstract symbolism, we explored research in semiotics in an attempt to choose a grammar. Several alternatives such as the grammar of Conceptual Dependency Theory (Schank, 1975; Schank, & Abelson, 1977) remain to be explored. However as an anchor point for our first proposal we quote from *An Introduction to Functional Grammar* (Halliday, 1985): "Our most powerful conception of reality is that it consists of 'goings-on': of doing, happening, feeling, being." Halliday identifies the three most common types of processes: material processes, mental processes and relational processes. These categories seem amenable to representation. We shall begin by symbolising examples of the three processes, considering each process in turn.

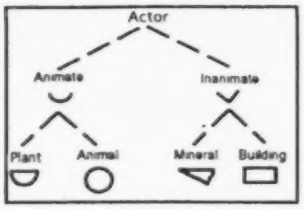
1. Material processes: processes of doing. Here we have the common "Actor, Process and Goal" construct that suggests animation. We can animate actions for walk, run, jump, dance, break, make, give, take, etc.
2. Mental processes: processes of sensing. Since these can be regarded as directed actions we shall indicate them by dynamic lines or arrows. For example, love can be a golden shaft directed towards the object. Liking will be represented by a less intense yellow while hate will be brown or black. Directed fear and worry will be jagged shafts.
3. Relational processes: processes of being. Here we shall consider two classes: those that are attributes of the object and those which can be considered as states of the object. Attributes we shall assign as associated symbols as described in Section 7. States we can indicate by colouring objects, for example, pink for happy and blue for sad.

7. Using Abstract Symbols

The basic symbols we introduce will need to be simple – yet be beautiful in their own right. The more frequently a symbol is used the simpler it should be. Additional characteristics will be added by association and only when needed. Obviously we shall not have to introduce new symbols for all words: we shall include accepted signs, (Liungman, 1991), such as an X for "forbidden", and we can have dictionaries of known shapes and symbols to call on. As noted in Section 3 we shall try to avoid using shapes that are too lifelike, partly because this limits the reader's imagination and partly because using abstract symbols gives us more freedom to add attributes without contravening our built-in sense of appropriateness. For example, while it may be quite inappropriate to paint a life-like symbol of a beautiful woman a golden yellow colour, a golden circle definitely transmits the idea of beauty.

There are two distinct facets to abstraction: abstraction of appearance and abstraction of senses (feeling, thinking and emotion). As described above, a golden circle may represent beauty of appearance. But beauty applies just as significantly to the abstract, and it is qualities such as feelings, thoughts and emotions that have proved difficult for existing visual forms of communication. Abstract symbols can take on additional attributes with no conflict. Beautiful feelings, beautiful thoughts, beautiful emotions: all can be abstractly displayed as golden states. Even speech (or thought) balloons which look clumsy on lifelike characters may be artistically attached to symbols.

We shall begin by introducing basic symbols using the following classification system:



7.1 The Addition of Attributes

We shall be able to modify basic symbols by associating attributes. These modifiers may be either one or more associated symbols, or an integral part of the basic symbol, such as colour. For example, if we introduce the common biological symbols: ♀ (Female) and ♂ (Male), then we have symbolic representations for:

♀ (Female animal) and ♂ (Male animal).

Using the symbol ~ to represent "intelligent" (for "brain waves") these can be further modified to represent:

♀ (Woman) and ♂ (Man).

7.2 Applying the Principle of Orthogonality

The term "orthogonality" was introduced by Aad van Wijngaarden in the design of programming languages, to mean features that carry across from one context to another (Wijngaarden, 1965). To ease learning we shall build into MUSLI as much orthogonality as possible.

For example, we can define: Female plant Male plant Bisexual plant

If we now introduce the additional attributes: + (Medical), ♣ (Holy) and ▯ (Manufacturer) together with the symbols 🚗 to represent a four wheeled vehicle and ⛰ to represent a mountain, we can now form the following definitions:

Doctor Hospital Ambulance Medicinal plant Factory School Holy building Holy mountain

We can introduce additional conventions that will communicate variations in such attributes as age (an increasingly thick outline) or sickness (a cracked or broken symbol).

7.3 Condensing a Group of Symbols

If the attributes in a group are relatively constant then the original symbol plus attributes can be replaced by a condensed short-form. We shall use a frame, ▭, to group primitives and / to represent condensation.

E.g. a working (manufacturing) intelligent woman condensing to: ◝ , and a wise old solitary man (i.e., a hermit) condensing to ◟, is represented by:

and

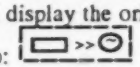
Compound symbols can be condensed at any stage either by the reader pausing and clicking on them or by the system converting them. Usually the reader will need warning before a symbol condenses and this can be achieved in a variety of ways. Perhaps the compound symbol will have its border change colour before the

change or both symbols may be displayed at once with the compound one gradually decreasing in size while the condensed symbol increases. Interesting possibilities of letting an electronic personal assistant control the degree and timing of the condensations remain to be explored.

The condensed symbols will be animated just as groups of primitives can be. A working (manufacturing) woman carrying water may be either or and might be shown moving towards a growing (manufacturing) plant . We would then, of course, see the attribute for growing increase in size!

Again we emphasise that we are not producing cartoons: the symbols, like those shown above, will have to be learnt. They are not intended to be immediately obvious, but to carry meanings that will not be forgotten once learnt.

7.4 Expanding Condensed Symbols

Expanding symbols is the reverse process to condensing symbols. As mentioned in Section 3, readers will be able to freeze the display at any point in time and then, for example, by double-clicking on a compound symbol display the original primitives. Thus double-clicking on the symbol for a vehicle, , may expand it back to:  – where >> is the symbol for motion (since a vehicle is an inanimate object moving people).

8. Bringing it All Alive With Dynamic Symbols

At this point the reader may be forgiven for wondering whether we are not simply reinventing a system of hieroglyphics. The difference is that people such as the Egyptians did not have ways to animate their written symbols!

In a MUSLI document objects can move and change with time, and hence we frequently refer to it as a movie. Describing dynamic processes is not easy and of course we look forward to the day when we shall be writing a MUSLI movie instead of static text!

We shall begin by very briefly indicating how we might dynamically represent each of the processes introduced in Section 6. First of all it is easy to see how we can animate the material processes of doing. Symbols can be made to move on the screen in ways that suggest walking, running, jumping, dancing, breaking, and making – for "making" we can show the parts coming together to form a whole. For the cases of giving and taking we suggest introducing a dynamic shaft with an arc at the end of it. On object is "given" by letting the shaft extend and "push" the object away. An object is "taken" when it is drawn in closer to the subject as the shaft shortens.

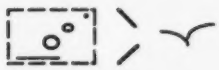
Secondly, mental processes of sensing, which we represent by dynamic lines, will continuously change in position, length, width, colour and intensity. The golden shaft of love, reaching out towards its object, may become more or less intense in colour as the movie continues. A child's initial fear of a doctor will be palpably obvious when shown by a pulsating black jagged arrow and with time the fear may fade (literally) and morph into the symbol for respect.

Thirdly there are the relational processes of being. Besides the attributes that are assigned as associated symbols, as described in Section 7, there are the emotions, which we can indicate by shading the object different colours. Here again the dynamic nature of our medium allows emotions to change in a continuous spectrum – as of course they do in real life. Conflicting emotions can be beautifully depicted by showing an animated interplay between the colours representing rivalling emotions – both colours and intensities can interact.

Attributes can also be dynamic. A symbol that depicts an animal slowly ascending a mountain can certainly suggest a very high mountain.

Going one step further, symbols themselves may be formed from animated sequences. A simple circle representing an animal "flying" off a base line can represent a bird flying,

Of course this can be condensed:



And again, the condensed symbol can be animated – in this case by letting the wings move. And so on!!

The modifiers may also change with time. The symbol representing "immature" may morph into the symbol for "sophisticated" as the character in a story gains experience.

At this point we would like to change our point of view to the "other side of the mountain" and make a brief reference to the language for cosmic intercommunication: LINCOS (Freudenthal, 1960). The author hypothesises that the "reader" can deduce meaning from the given graded series of examples. New words are introduced one at a time and the hypothesis is that if the number of examples read is large enough then the reader will deduce from its context the intended meaning for each newly introduced "word" (in this case a word is a pattern of radio pulses). This principle can obviously be applied to MUSLI movies, particularly those that contain symbols for abstract ideas. Although LINCOS deliberately avoids "showing" as a means for illustrating meaning, MUSLI can use dynamic symbols to represent abstract concepts such as number. We can successively display two plants, two animals, two vehicles, and so on, before condensing the dynamic symbol down to a static one. Once the numeric symbols have been introduced we can then dynamically introduce the symbol for the set of natural numbers, etc. The LINCOS exercises introducing the rules of number would in themselves make appropriate MUSLI movies for introducing algebra.

We can also use dynamic symbols for other abstract ideas such as "human". In this case the dynamic symbol would show various subsets of the set [man, woman and child] before condensing to the symbol for human. An idea like "medical" can be formed by demonstrating its adjectives.

We are very aware of how much we have left undone but we look forward to delving deeper. We refer the reader to the paper "DynamIcons as Dynamic Graphic Interfaces: Interpreting the Meaning of a Visual Representation", (Jonassen, Goldmann-Segall, & Maurer, 1993), for an exposition on moving icons.

9. Examples

It is very difficult in a printed paper such as this to describe what are essentially highly dynamic processes. We shall outline just a few.

Our first abstract document, produced in Macromind Director, was an exceedingly simple yet surprisingly convincing movie of a sick child's visit to hospital. The animated symbols show clearly the bonding between the mother and child. The trip into the hospital and the child's recovery were also easily animated.

In our current project, a little more ambitious, we plan to produce a presentation, and possibly a CD version, of a MUSLI movie which depicts a city plagued by smog. The interactions between citizens and administrators lend themselves well to dynamic representations. At the beginning the interactions are overtly hostile but they change dramatically with time. The solution to the crisis is a novel one as it neither bans personalised transport nor enforces public systems[1].

We would like to see a hypermedia system implemented where the user can be provided with interactive MUSLI movies corresponding to alternative search paths through the network – complete with symbols indicating the type of links that are used and what kind of data is available on the way.

And imagine how much more enjoyable it would be coping with e-mail presented in a MUSLI setting with dynamic symbols – particularly if we had an electronic personal assistant to help us!

10. Conclusion

Even a superficial survey of signs and symbols shows the richness of our semiotic heritage. The system we propose will be flexible enough to blend traditional forms of documentation into modern multimedia information retrieval systems while gradually becoming enriched with its own symbolic language. MUSLI

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1 The small low-powered individualised units which are used for short trips can be coupled together, as required, with the rightmost vehicle assuming control. For longer journeys the various units, together with their passengers, are driven onto high speed public transportation vehicles. Individual drivers and passengers relax in their own seats or take advantage of on-board facilities such as dining cars and boutiques and may even find time and opportunity for an overdue haircut!

enables "reading" at different levels using an extended version of a reference system, and makes maximal use of the principle of orthogonality to aid learning. We discuss the necessary general requirements for a symbolic language before making a first concrete proposal based on the principles of functional grammar. We are aware that the mastery of any new language involves effort, but surely we can take heart from the success of other interactive activities such as video games.

The system we have described is a first step towards mastering the art of electronic communication involving all our senses, so that we can reap the real benefits associated with a new age of hypermedia.

It seems appropriate to conclude a paper such as this with a quote from a Gary Larson cartoon. The medieval soldiers are fighting to grim death on the battlements of the castle. Arrows and spears are flying thick as rain. Then one soldier turns to another and remarks that it doesn't really matter whether they win or lose: it's fun! This is how we feel about MUSLI: it is not yet clear whether the eventual outcome will be a revolution in communication and language, or a modest addition to the theory of semiotics. One thing is clear: MUSLI is fun.

We hope that this first glimpse will encourage many readers to join us in further exploration of MUlti Sensory Language Interfaces.

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